



REVIEW OF EXISTING TEXTILE-COVERED SPORTS FACILITIES IN NIŠ, SERBIA

Review paper
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ABSTRACT: Textile architecture in Serbia is predominantly present in its simpler forms. In most existing buildings, textile membranes are used only as a covering material, without the significant double curvature required to fully exploit their structural and architectural potential. This research focuses on sports facilities covered with textile membranes in the city of Niš. The aim of the study is to identify and systematize existing buildings of this typology. The results show that there are currently 20 such facilities in the wider area of the city. These facilities were visited, and relevant data were recorded and analyzed, with the results presented and discussed in this paper. In addition, six other textile-covered structures were identified but fall outside the scope of this research. These include four storage facilities, one protective cover for a historical site, and one canopy covering a restaurant garden. The analyzed textile structures exhibit significant diversity in several aspects, including ownership, structural system, permanence, and function. The findings of this study will be used to inform the development of improved textile cover designs for sports facilities in the region.

Keywords: Textile architecture, textile membranes, sports facilities, textile buildings.

PREGLED POSTOJEĆIH SPORTSKIH OBJEKATA POKRIVENIH TEKSTILNIM MEMBRANAMA U NIŠU, SRBIJA

APSTRAKT: Tekstilna arhitektura u Srbiji pretežno je prisutna u svojim jednostavnijim oblicima. U većini postojećih objekata, tekstilne membrane se koriste samo kao pokrivni materijal, bez značajne dvostruke zakrivljenosti koja je potrebna da bi se u potpunosti iskoristio njihov konstruktivni i arhitektonski potencijal. Ovo istraživanje se fokusira na sportske objekte pokrivenne tekstilnim membranama u gradu Nišu. Cilj rada je identifikacija i sistematizacija postojećih objekata ove tipologije. Rezultati pokazuju da se trenutno na širem području grada nalazi 20 takvih objekata. Ovi objekti su posećeni, a relevantni podaci su prikupljeni i analizirani, pri čemu su rezultati prikazani i razmatrani u ovom radu. Pored toga, identifikovano je još šest objekata pokrivenih tekstilom, ali oni ne



spadaju u obuhvat ovog istraživanja. To uključuje četiri skladišta, jednu zaštitnu konstrukciju za istorijski lokalitet i jednu nadstrešnicu koja pokriva baštu restorana.

Analizirane tekstilne konstrukcije pokazuju značajnu različitost u mnogim aspektima, u pogledu vlasništva, primenjenog konstruktivnog sistema, stalnosti i funkcije. Rezultati ovog istraživanja biće korišćeni kao osnova za razvoj unapređenih rešenja tekstilnih pokrivača za sportske objekte u regionu.

Ključne reči: Tekstilna arhitektura, tekstilne membrane, sportski objekti, tekstilni objekti.

1. INTRODUCTION

Textile architecture has become increasingly popular over the past 50 years. In many countries, it is widely used across different building typologies. The reasons for using textile materials on roofs or façades are sometimes aesthetic, due to their attractive curvature, and sometimes practical, owing to the numerous benefits they offer. Compared to traditional building materials, architectural textiles are not only visually appealing but also extremely lightweight, possess high tensile strength, are easy to transport, relatively inexpensive, and durable. On the other hand, the technological processes involved in their development are complex and still not fully optimized, particularly in terms of the reliability of mechanical properties.

It is generally considered that the full potential of textile architecture is not yet utilized in Serbia and that such buildings are less common than in more developed countries. The conducted research confirms that textile buildings are indeed less numerous, despite the presence of experts in this field. However, the investigation also revealed a disproportion in the distribution of textile buildings by typology. The majority are sports facilities, followed by industrial storage structures, while other types are rare. This research therefore focuses on textile-covered sports facilities.

Previous studies have investigated various aspects of textile membrane roofs. The most common topics include thermal comfort [1–3] and energy performance [4,5]. A specific subtype includes air-supported textile membrane structures [6,7]. The most frequently analyzed typologies are industrial [8] and sports facilities [9–11]. Identification studies of textile-covered sports facilities have been conducted in the region [12], while examples from Italy are presented in [13]. Advanced textile structures in Serbia have also been analyzed [14].

This research reviews existing sports facilities covered by textile membranes in the wider area of the city of Niš. The goal is to identify and document all such buildings to establish a foundation for further detailed analysis. The resulting database will be used to assess their architectural and structural characteristics and to support the development of optimized design solutions. It is expected that the findings will contribute to promoting textile architecture in the region.



2. METHODOLOGY

The geographical scope of the research is limited to the wider area of the city of Niš, the third-largest city in Serbia. The city has approximately 180,000 inhabitants, while the wider area includes around 250,000. The climate is moderate continental, with an average annual temperature of 11.9°C, approximately one rainy day in three, and an elevation of about 200 m. Niš is located in the southeastern part of the country, along an important transit route between Europe and the Middle East. It was selected as the initial case study, with the intention of extending similar research to other major cities.

The study focuses exclusively on sports facilities, although other textile-covered structures exist in the city. This focus was chosen because sports facilities represent the dominant typology and therefore provide the most comprehensive dataset. Only medium- to large-span structures were considered, excluding textile roofs with spans smaller than 10 m. The analysis was conducted between January and April 2026.

The research began with the identification of textile-covered buildings in Niš. Initial data were collected through informal interviews with athletes, followed by internet searches and map-based analysis. After compiling a preliminary list, each identified building was visited in person. Data on architectural and structural characteristics were recorded during these visits.

Due to the lack of access to official design documentation, certain data, such as the exact type of textile material, could not be obtained. Consequently, the research focused on observable and accessible characteristics. This paper presents the locations and exterior views of the identified buildings, while other relevant aspects are analyzed and discussed. The conclusions drawn from this phase will inform subsequent stages of the research.

3. RESULTS AND DISCUSSION

The conducted analysis identified 26 textile buildings in the wider area of Niš. Among these, there were six buildings that fall outside the scope of the research. These include one large-span structure used as a protective cover of the historical site Medijana, which contains a Roman complex in the eastern part of the city, and one double-cone cover of a restaurant garden in the northern part of the city. Additionally, there are four industrial textile buildings: a small one in the north, two that are part of a milk factory in the far northwest, and one storage facility of a retail store in the west. They are marked with orange tags in Figure 1. The remaining 20 are all sports facilities. Their locations on the city map are shown in Figure 1 as blue circles.

In Figure 1, these buildings are numbered starting from the east; however, building number 20 is intentionally labeled last. The reason for this is that the building existed when the research began; nevertheless, the textile cover was dismantled before the physical visit to the facility. Therefore, it is known that this textile roof existed, and some data about it are available from the owner and historical imagery on Google Earth, but the researchers did not have the opportunity to analyze and document this building in detail. Table 1 presents

exterior views of the 19 visited facilities. Facilities 13, 14, and 15 are presented in a single photograph.

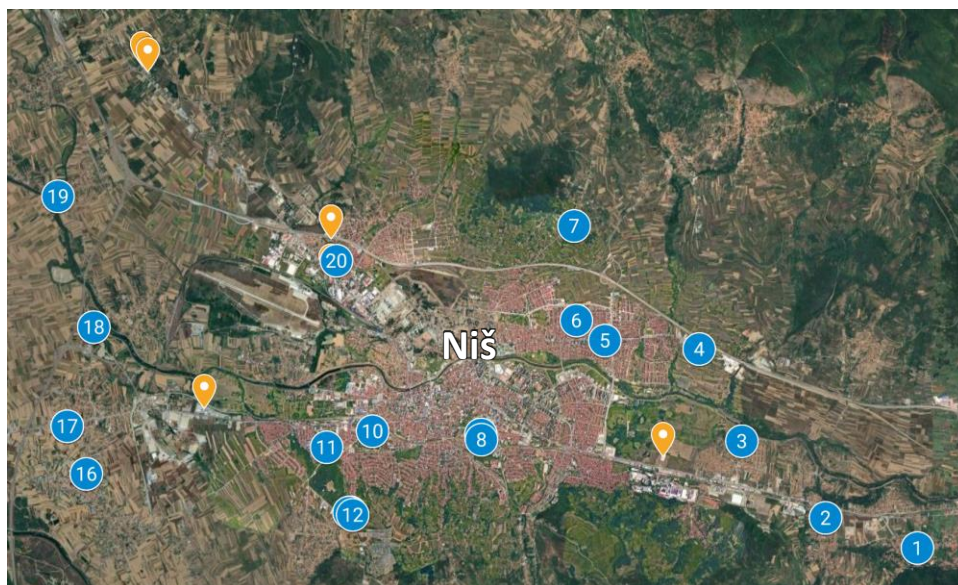


Figure 1: Locations of textile-covered sports facilities in Niš (based on Google Earth)

The discussion of the existing textile-covered sports facilities is conducted with respect to several aspects, including location, ownership, structural system, permanence, structural condition, and function. Among the visited facilities, six are located in the city, five are on the outskirts, and eight are in surrounding settlements and villages. These buildings are usually completely free-standing or, in some cases, connected to other buildings and annexes. Buildings 8 and 9 are located close to each other but are completely independent. Buildings 12, 13, 14, and 15 are part of the same sports complex, although building 12 is separate from the others. The remaining three buildings are positioned next to each other and connected along their longer sides.

With regard to ownership, several cases are present. Eight buildings are constructed on the grounds of primary schools in order to provide gym facilities for students who did not previously have access to covered spaces for physical education. Some of these are rented after school hours, generating additional income. Nine facilities are privately owned and operate as commercial venues, offering rental options for individual athletes and sports clubs on an hourly basis. One facility is owned by the municipality of Niška Banja, and another is part of the sports center Čair; both operate according to schedules defined by their respective owners.

There are two basic subtypes of textile membrane structures: mechanically prestressed and pneumatically prestressed. Mechanically prestressed membranes require a rigid supporting



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structure for stability. Depending on the membrane form, it can generally be concluded that structures with significant double curvature require fewer supports, whereas those dominated by single curvature require more. In pneumatic membrane structures, stability is achieved through differences in air pressure. These can be single-layered, where internal air pressure is higher, or multi-layered, where the pressure between layers is increased. In Niš, both mechanically and pneumatically prestressed textile roofs are present. Mechanically prestressed systems are dominant, with 18 such sports facilities identified. Only one existing facility (number 8) and facility 20 (now dismantled) belong to the pneumatic type. In both cases, simpler structural solutions are used, characterized by dominant single curvature and single-layer air-supported membranes.

Another way to categorize textile membrane roofs is by their permanence. Two primary categories exist: permanent and temporary. A third possibility is retractable roofs, which, although not uncommon globally, are more complex and financially demanding, typically requiring additional supporting structures. Such high-end solutions are not yet present in Niš. Permanence is closely related to the structural system: mechanically prestressed membranes are generally permanent, while pneumatically prestressed structures may be either temporary or permanent. In the local climate, pneumatic membranes are often used as temporary winter enclosures and dismantled during warmer months to allow open-air use. This was the case with facility 20, which was dismantled before it could be studied. It is expected that facility 8 will also be dismantled in April and reinstalled in late autumn.

Regarding function, the textile-covered sports facilities in Niš exhibit a moderate degree of diversity. Their function is primarily determined by the type of flooring rather than the roof structure. Three main types of flooring are used: artificial turf, clay, and hard surfaces. Artificial turf is used for indoor football fields, while clay is used exclusively for tennis courts. Hard surfaces, made from various materials, support sports such as basketball, volleyball, futsal, tennis, and handball. Adequate interior height is essential to accommodate these activities. Facility 9 is particularly notable, as it undergoes a seasonal transformation: the hard floor is replaced with an ice surface during winter, converting it into an ice-skating rink. Although examples exist elsewhere in Serbia of swimming pools covered with textile membranes, such cases are not present in Niš.

One unexpected finding relates to the structural condition of these facilities. Although most were constructed 10–15 years ago, a significant number exhibit serious damage. Facility 6 is completely out of use and lacks its textile cover. Facility 10 has a partially torn membrane, while facility 16 shows similar damage, with sections of the roof and both gable walls destroyed. Facility 19 has entirely lost its roof membrane, with only fragments of the textile walls remaining. In total, 4 out of the 19 surveyed facilities are non-operational due to severe structural damage. All of these are located within primary school complexes. Their condition has persisted for several years, and reconstruction has been anticipated but not yet realized. Historical evidence indicates that additional textile-covered sports facilities once existed in Niš but have since been removed. At the same time, new facilities are expected to be constructed in the near future.

Table 1: Exterior views of visited textile-covered sports facilities (authors' archive)



4. CONCLUSION

This research investigates existing textile membrane roofs used in sports facilities in the wider area of Niš. This building typology was selected due to its prevalence among textile



structures in the region. The primary goal of the study was to identify and document existing facilities to establish a foundation for more detailed future analysis. The list of facilities was compiled through interviews with athletes and online research. As a result, 20 buildings were identified within the study area and subsequently visited. However, one temporary structure was dismantled before the visit, so detailed data were collected for 19 facilities.

The results indicate that there is approximately one textile-covered sports facility per 13,000 inhabitants in the analyzed region. This paper presents their locations and exterior appearances, along with a systematic discussion of their main characteristics. It was determined that all facilities belong to relatively simple forms of textile membrane structures. Ownership is divided between private and public sectors; however, four publicly owned facilities have been severely damaged for an extended period. Most facilities are designed as permanent structures, while only two are seasonal installations used exclusively during winter. Their functions include indoor football, tennis, and various indoor sports such as basketball, futsal, handball, and volleyball. In one case, the facility is seasonally converted into an ice-skating rink.

This study is focused on a specific building typology and structural system. A key limitation is the lack of detailed data regarding the exact type of textile material used in each facility. The data collected in this phase will be further analyzed in subsequent stages of the research. Future work will include detailed evaluation of structural performance, functionality, thermal comfort, energy efficiency, and lighting conditions. The ultimate objective is to develop improved design solutions for textile-covered sports facilities, thereby enhancing their performance and promoting broader application of textile architecture in the region. Such a result would provide better conditions for athletes and spectators, as well as benefits for the owners of textile buildings.

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REFERENCES

- [1] Hu, J., Chen, W., Zhang, S., Yin, Y., Li, Y., Yang, D. (2018). Thermal characteristics and comfort assessment of enclosed large-span membrane stadiums, *Applied Energy*, 229, 728–735.
- [2] Bai, Y., Zhao, L., Tang, R., Kang, X. (2022). Study on winter thermal comfort of membrane structure gymnasium in severe cold region of China, *Science and Technology for the Built Environment*, 28, 499–511.



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- [3] Li, R., Liu, Y., Yu, G., Guo, H., Qin, S. (2023). Establishment of a thermal comfort model for spectator areas of air-supported membrane ice rinks in severe cold regions: A case study in Harbin, China, *Energies*, 16, 4598.
 - [4] Randelović, D., Vasov, M., Kostić, D., Jovanović, V., Savić, J., Anđelković, A. (2025). Energy efficiency and indoor microclimate in balloon halls: a case study on thermal stability and ventilation simulation, *Proceedings of the 10th International Conference on Smart and Sustainable Technologies (SpliTech 2025)*, Split–Bol, Croatia, 16–20 June 2025.
 - [5] Hu, J., Kawaguchi, K., Ma, J. (2019). Retractable membrane ceilings for enhancing building performance of enclosed large-span swimming stadiums, *Engineering Structures*, 186, 336–344.
 - [6] Alongi, A., Angelotti, A., Rizzo, A., Zanelli, A. (2021). Measuring the thermal resistance of double and triple layer pneumatic cushions for textile architectures, *Architectural Engineering and Design Management*, 17(3–4), 334–346.
 - [7] Tariq, I., Chen, W., Yue, Y., Gao, C. (2026). Long-term thermal performance analysis of an air-supported membrane structure with advanced thermal insulation design, *Energy and Buildings*, 351, 116743.
 - [8] Tian, G., Fan, Y., Wang, H., Peng, K., Zhang, X., Zheng, H. (2020). Studies on the thermal environment and natural ventilation in industrial building spaces enclosed by fabric membranes: A case study, *Journal of Building Engineering*, 32, 101651.
 - [9] Hu, J., Kawaguchi, K., Ma, J. (2020). Long-term building thermal performance of enclosed large-span swimming stadiums with retractable membrane ceilings, *Energy and Buildings*, 207, 109363.
 - [10] Suo, H., Angelotti, A., Zanelli, A. (2015). Thermal-physical behavior and energy performance of air-supported membranes for sports halls: a comparison among traditional and advanced building envelopes, *Energy and Buildings*, 109, 35–46.
 - [11] Lu, S., Qian, H., Guo, Q., Gu, M. (2023). Energy-saving performance and mechanism studies on membrane ceiling: a case study of the National Speed Skating Oval, *Energy for Sustainable Development*, 72, 88–99.
 - [12] Milošević, V., Đurić Mijović, D., Kostić, D., Vacev, T. (2025). Membrane-covered sports facilities in Podgorica, Montenegro – identification, *City in Crisis*, Kołobrzeg, Poland.
 - [13] Silvestri, A., Paraciani, N., Villani, T. (2020). Performance evaluation of textile materials for lightweight envelopes in minor sports facilities and their impact on indoor comfort, *Architectural Engineering and Design Management*.
 - [14] Milošević, V., Kostić, D. (2022). Odabrane izvedene membranske konstrukcije u Republici Srbiji, *Nauka+Praksa*, 25, 27–34.